APPENDIX C

PROCEDURES FOR PRESSURE AND LEAKAGE TESTING OF MAINS

KANSAS DEPARTMENT OF HEALTH & ENVIRONMENT
Division of Environment
Bureau of Water

PROCEDURES FOR PRESSURE AND LEAKAGE TESTING OF MAINS

All newly installed mains must be pressure and leakage tested prior to final acceptance. This memorandum provides recommended standards for pressure and leakage testing for ductile iron and PVC water mains. These recommendations closely follow AWWA Standards and industry specifications. The applicable AWWA Standards are contained in C600-93 for ductile iron mains and C605-94 for PVC mains. Pressure and leakage testing requirements for materials other than ductile iron or PVC will be determined on a case by case basis. Alternate pressure and leakage criteria for ductile iron or PVC mains are acceptable provided they are shown to be at least as stringent as the criteria presented in this memorandum or applicable AWWA Standards.

Simultaneous or separate pressure and leakage tests may be performed. The test durations and pressures for each option are specified in Table 1. If separate tests are made, the pressure test should be conducted prior to the leakage test.

TABLE 1 - Pressure and Leakage Test Methods

Procedure	Test Pressure	Duration of Test
Simultaneous Pressure & Leakage Tests	150% of working pressure* at point of test, but not less than 125% of normal working pressure at highest elevation.	2 Hours
Separate Pressure Test	150% of working pressure* at point of test, but not less than 125% of normal working pressure at highest elevation.	1 Hour
Separate Leakage Test	150% of working pressure* of segment tested.	2 Hours

*Working pressure is defined as maximum anticipated sustained operating pressure. However, in no case shall the test pressure exceed the pressure rating for the pipe, valves, appurtenances, or thrust-restraints.

Pressure Test

The purpose of the pressure test is to locate defects in materials or workmanship. Before testing, the pipeline must be backfilled and braced sufficiently to prevent movement under pressure. If concrete thrust blocks are used, sufficient time must be allowed before testing to ensure that the concrete has cured sufficiently. The test ends also should be restrained to withstand thrusts potentially developed under the test pressures.

A pressure test should be conducted at 150% of the working pressure in the line. The working pressure is defined as the maximum anticipated sustained operating pressure in the line being tested. Care must be taken not to exceed the pressure rating of pipes, valves, fittings, thrust restraints, or other appurtenances. Pressures greater than specified for the test may be erroneously created in the main if the water pressure is read from a gauge located at a high point in the line.

Potable water is introduced into the main through a temporary connection to a hydrant, corporation stop in the new main, or through a valved connection with the existing line. While filling the new main, air must be expelled from the pipeline by venting through service connections, hydrants, or air-release valves. Corporation stops may be required at high points in the line if there are insufficient valves to release air from the main. It is important to completely expel air from each section of the main to be tested. Compressed entrapped air may amplify surges within the main or cause erroneous pressure test results.

After filling the main with water and expelling air, a pump is utilized to increase the water pressure within the line up to the required test pressure and to maintain that pressure for the required duration (see Table 1). An accurate method for measuring the amount of water pressure within the line must be provided. A key criterion for the pressure test is that the measured water pressure within the main (after reaching the required test pressure) should not vary by more than 5 psi during the duration of the test. While the line is under pressure, the system and all exposed pipe, fittings, valves, and hydrants should be examined for leakage. Any damaged or defective pipe, fittings, valves, hydrants, or joints should be repaired or replaced and the pressure test repeated until satisfactory results are obtained.

Leakage Test

The purpose of the leakage test is to establish that the section of main being tested, including all joints, fittings and other appurtenances, will not leak or that leakage is within acceptable limits. If the leakage test is to be performed simultaneously with the pressure test, the system should be allowed to stabilize at the test pressure before conducting the leakage test.

Equipment necessary for conducting the leakage test include a pump equipped with a make-up reservoir and a pressure gauge for measuring water pressure in the main. In addition, there must be an accurate method for measuring the quantity of water pumped into the main being tested. Methods used to measure water volume include a calibrated make-up reservoir, a calibrated positive-displacement pump, or a water meter.

The specified test pressure for the leakage test is the same as for the pressure test (see Table 1) and the test should be conducted for at least 2 hours in duration. Leakage is defined as the quantity of water that must be supplied into the main in order to maintain the water pressure within 5 psi of the specified

test pressure after the pipe has been filled with water and air expelled. No pipe installation will be acceptable if the leakage is greater than that determined by the following formulas:

For PVC pipe,

$$L = \frac{ND\sqrt{P}}{7,400} \qquad (Eq.\ 1)$$

where,

L = allowable leakage, in gallons per hour
N = number of joints in the length of pipeline tested
D = nominal diameter of the pipe, in inches
P = average test pressure during the leakage test in pounds per square inch

Eq. 1 is based on an allowable leakage of 10.5 gpd/mi/in of nominal diameter at a pressure of 150 psi. Leakage values determined by the above formula for 50 joints are presented in Table 2.

TABLE 2 - ALLOWABLE LEAKAGE (gal/hr) FOR PVC PLASTIC PIPES PER 50 JOINTS

Nominal Pipe Size (In)	Average Test Pressure in Pipeline, psi										
	50	75	100	125	150	175	200	225	250	275	300
2	0.10	0.12	0.14	0.15	0.17	0.18	0.19	0.20	0.21	0.22	0.23
4	0.19	0.23	0.27	0.30	0.33	0.36	0.38	0.41	0.43	0.45	0.47
6	0.29	0.35	0.41	0.45	0.50	0.54	0.57	0.61	0.64	0.67	0.70
8	0.38	0.47	0.54	0.60	0.66	0.72	0.76	0.81	0.85	0.90	0.94
10	0.48	0.59	0.68	0.76	0.83	0.89	0.96	1.01	1.07	1.12	1.17
12	0.57	0.70	0.81	0.91	0.99	1.07	1.15	1.22	1.28	1.34	1.40
14	0.67	0.82	0.95	1.06	1.16	1.25	1.34	1.42	1.50	1.57	1.64
16	0.76	0.94	1.08	1.21	1.32	1.43	1.53	1.62	1.71	1.79	1.87
18	0.86	1.05	1.22	1.36	1.49	1.61	1.72	1.82	1.92	2.02	2.11
20	0.96	1.17	1.35	1.51	1.66	1.79	1.91	2.03	2.14	2.24	2.34
24	1.15	1.40	1.62	1.81	1.99	2.15	2.29	2.43	2.56	2.69	2.81
30	1.43	1.76	2.03	2.27	2.48	2.68	2.87	3.04	3.21	3.36	3.51
36	1.72	2.11	2.43	2.72	2.98	3.22	3.44	3.65	3.85	4.03	4.21

Note: If the pipeline under test contains sections of various diameters, the allowable leakage will be the sum of the computed leakage for each size.

For ductile iron pipe,

$$L = \frac{SD\sqrt{P}}{133,200} \qquad (Eq.\ 2)$$

where,

L = allowable leakage, in gallons per hour
S = length of pipe tested, in feet
D = nominal diameter of the pipe, in inches
P = average test pressure during the leakage test, in pounds per square inch

Eq. 2 is based on an allowable leakage of 11.65 gpd/mi/in of nominal diameter at a pressure of 150 psi. Leakage values determined by the above formula for 1,000 ft of DIP pipe are presented in Table 3.

TABLE 3 - ALLOWABLE LEAKAGE (gal/hr) FOR 1000 FT OF DUCTILE IRON PIPE

Avg. Test Pressure	Nominal Pipe Diameter - in.										
(psi)	3	4	6	8	10	12	14	16	18	20	24
100	0.23	0.30	0.45	0.60	0.75	0.90	1.05	1.20	1.35	1.50	1.80
125	0.25	0.34	0.50	0.67	0.84	1.01	1.18	1.34	1.51	1.68	2.01
150	0.28	0.37	0.55	0.74	0.92	1.10	1.29	1.47	1.66	1.84	2.21
175	0.30	0.40	0.60	0.79	0.99	1.19	1.39	1.59	1.79	1.99	2.38
200	0.32	0.42	0.64	0.85	1.06	1.27	1.49	1.70	1.91	2.12	2.55
225	0.34	0.45	0.68	0.90	1.13	1.35	1.58	1.80	2.03	2.25	2.70
250	0.36	0.47	0.71	0.95	1.19	1.42	1.66	1.90	2.14	2.37	2.85
275	0.37	0.50	0.75	1.00	1.24	1.49	1.74	1.99	2.24	2.49	2.99
300	0.39	0.52	0.78	1.04	1.30	1.56	1.82	2.08	2.34	2.60	3.12
325	0.41	0.54	0.81	1.08	1.35	1.62	1.89	2.17	2.44	2.71	3.25
350	0.42	0.56	0.84	1.12	1.40	1.69	1.97	2.25	2.53	2.81	3.37
375	0.44	0.58	0.87	1.16	1.45	1.74	2.04	2.33	2.62	2.91	3.49
400	0.45	0.60	0.90	1.20	1.50	1.80	2.10	2.40	2.70	3.00	3.60

Note: If the pipeline under test contains sections of various diameters, the allowable leakage will be the sum of the computed leakage for each size.

When testing against closed metal-seated valves, an additional leakage per closed valve of 0.0078 gal/h/in of nominal valve size is allowed.

Leakage less than the quantity specified by Eqs. 1 or 2 may be considered "allowable leakage" resulting from such factors as trapped air, take-up of restraints, and temperature variations during testing. However, observed leaks should be repaired regardless of leakage measurements through metering equipment.

A swift loss of water pressure in the main could be the result of a break in the line, major valve opening, loose mechanical joint bolts, missing or dislodged gasket, or inadequate thrust block. A slow loss of pressure in excess of allowable limits could be the result of minor problems such as a leaking valve or a corporation stop not completely shut off. In addition, air entrapped in the line can result in leakage in excess of the allowable limit.

Recommendations for avoiding minor leaks include the following:

- Vent all high points in the line by use of air release valves or corporation stops.
- Check all mechanical joint bolted connections.
- Cure thrust blocks before testing.
- Insure that exposed gasket grooves are properly cleaned before inserting gaskets.
- When inserting pipe into a mechanical joint or gasket joint, insure that the spigot end is squarely cut and bevelled properly for the hub.

A procedure for determining if apparent leakage is the result of air entrapped in a line is the following: Repeat the leakage test and determine the amount of make-up water required to fill the line a second time. If this amount is significantly less than the first filling, the apparent leakage is probably the result of air being present in the line. If no significant difference in make-up water is recorded, a minor leak is probable.

Bibliography

1. "A Guide for the Installation of Ductile Iron Pipe", Ductile Iron Pipe Research Association, Birmingham, AL (1988).

2. *Handbook of PVC Pipe - Design and Construction*, Uni-Bell PVC Pipe Association, Dallas, TX (1991).

3. *Introduction to Water Distribution*, Vol 3, Principles and Practices of Water Supply Operations, American Water Works Association, Denver, CO (1986).

4. *PVC Pipe - Design and Installation* -- AWWA Manual of Water Supply Practices M 23, American Water Works Association, Denver, CO (1980).

5. "Standard for Installation of Ductile-Iron Water Mains and their Appurtenances -- C600-93", American Water Works Association, Denver, CO.

6. "Standard for Underground Installation of Polyvinyl chloride (PVC) Pressure Pipe and Fittings for Water -- C605-94", American Water Works Association, Denver, CO.